Volume 19 JULY 22, 1944 Number 4

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAMME

FOR THE

BERKELEY MEETING

AT

THE UNIVERSITY OF CALIFORNIA

BERKELEY, CALIFORNIA

JULY 22, 1944

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SIX ISSUES EACH YEAR

The American Physical Society

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Published six times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published six times a year during the months of January, April, June, July, November, and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary Karl K. Darrow, Columbia University, New York 27, N. Y.

Entered as second class matter, December 23, 1932, at the post office at Lancaster, Pa., under the Act of August 24, 1912.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.

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BERKELEY MEETING, JULY 22, 1944

THE 262nd Meeting of the American Physical Society, the 1944 "Summer Meeting in the West," will be held at the University of California, Berkeley, California, in Room 212 of LeConte Hall, on Saturday, July 22, 1944. There will be two sessions commencing at 9:30 A.M. and at 1:30 P.M., respectively. Following six contributed papers at the morning session, two invited papers will be given by Wayne E. Hazen and Edward U. Condon. The afternoon session will open with invited papers by Roy Overstreet and Joseph W. Weinberg, and these will be followed by the remainder of the contributed papers. Members and others in attendance will be enabled to take luncheon together, probably at the Faculty Club.

Prospective Meetings of the Society. It is intended to hold a meeting of the Society in or near Chicago about the middle of November, 1944; a meeting in Southern California in December, 1944, and a meeting (the "1944 Annual Meeting") in New York City about the middle of January, 1945. Attention is also drawn to the meeting of the American Association for the Advancement of Science at Cleveland from September 11 to September 16, 1944, at which the Society will probably be represented by its Ohio Section.

General Rules Relating to Papers

No paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at the most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of the abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

R. T. Birge,
Local Secretary for the Pacific Coast,
University of California,
Berkeley, California

JUL 3 '44

PROGRAMME

Saturday Morning at 9:30 O'Clock

Room 212, LeConte Hall

1. Cascade Showers in Lead. Wayne E. Hazen, *University of California.*—The calculations for number of electrons and positrons in a shower as a function of depth have been carried out lately to an accuracy of a few percent.[1] These latest calculations give curves for number of particles *versus* depth that are practically identical in shape with previous curves.[2] The important difference is that the corresponding curves are for initiating particles differing in energy by a factor of ~1.4. In photographs of a cloud chamber that contained eight lead plates, 50 complete cascade showers have been observed. The observed showers can best be compared with theory by plotting number of particles at the shower maximum *versus* total number of particles in the shower. Theory predicts essentially a straight line with slope 0.2. All but one of the experimental points lie above this straight line. The observed showers contain only one-half the predicted total number of particles for a given size of shower maximum. Since a large number of the electrons have energies as low as three Mev, it is possible that scattering and increase in ionization for $E<1.5$ Mev would account for the discrepancy.

[1] H. J. Bhabha and S. K. Chakrabarty, Proc. Ind. Acad. Sci. **A15**, 464 (1942).
[2] B. Rossi and K. Greisen, Rev. Mod. Phys. **13**, 240 (1941).

2. Growth of Water Drops in a Wilson Cloud Chamber. E. O. Barrett, *University of California.*—Water drops formed in a Wilson cloud chamber were photographed with periodic illumination and their velocity was measured. The drop size was determined by means of Stokes' law and the square of the radius of the drop was found to vary linearly with time as soon as the drop was large enough to register photographically. A 60-cycle neon light that moved with constant velocity during the exposure was turned on by the expansion valve. This light was photographed on the same frame and its flashes were used to establish the zero of the time scale for the drop images. It was observed that the straight line obtained from the experimental points intersected the time axis about 0.1 sec. after the zero. This fact seems to indicate that the rate of growth of the drops is smaller during the first 0.1–0.2 sec. and then reaches a constant value. The slope of the straight part of the curve was found to be 7.8×10^{-6} cm²/sec.

3. The Average Specific Ionization of Cosmic-Ray Mesotrons in Hydrogen. Lester L. Skolil, *University of California.*—Counter-controlled cloud-chamber photographs of cosmic-ray mesotron tracks in hydrogen have been taken. The chamber was operated in such a way that the average specific ionization could be obtained from the number of drops that condensed on positive ions. A triple-coincidence counter telescope was employed, with two counters below the cloud chamber and one above. Sufficient lead was placed above and below the top counter so that electron tracks could be distinguished from mesotron tracks. The average specific ionization, excluding energy transfers greater than 800 ev (clusters of more than thirty-two drops), is essentially 10.5 ion pairs per cm of hydrogen at N.T.P.

4. Radiofrequency Dielectric Properties of a Cellulosic System at Low Moisture Contents. W. C. Dunlap, Jr., and B. Makower, *Western Regional Research Laboratory.*—As background for a study of electrical moisture testing by radiofrequency methods, measurements were made of the radiofrequency dielectric properties of dehydrated carrots, a material typical of those on which such methods are used. Measurements were made of the dielectric constant ϵ and specific conductivity σ (a.c. and d.c.) as functions of moisture content (1.5–21.6 percent), temperature (1.5°C–39.8°C), frequency (18 kilocycles–5 megacycles), density (0.792–1.45 g/cm³) and particle size (small and medium). ϵ increases little with moisture content up to 6–8 percent; above this region ϵ increases rapidly. Increase of temperature increases both the value of ϵ and the rate of change of ϵ with moisture. At 1.5°C there is no detectable change of total σ with increase in moisture until 6–8 percent is reached; above this region the variation becomes exponential. At higher temperatures this apparent discontinuity disappears. Particle size has little effect upon ϵ or σ, for a given bulk density. Increase of bulk density increases ϵ and total σ uniformly on a logarithmic scale for all frequencies. A brief discussion will be given of the theory of the properties observed.

5. Control of Glycol Vapor Concentration in Room Air. C. E. Nielsen, *Department of Physics,* and K. B. DeOme, *Division of Veterinary Science, University of California.*—The vapors of certain glycols, non-toxic to man, are effective in killing air-borne bacteria. The effectiveness depends critically both upon the amount of water vapor and upon the amount of glycol vapor present. In consequence, satisfactory clinical experiments cannot be made without stabilizing both humidity and glycol vapor pressure. Although humidity is controllable, no method of controlling glycol vapor pressure under room conditions has been devised. The Wilson cloud chamber offers an approach to this problem. When room air is cooled by adiabatic expansion, droplets will grow upon nuclei normally present if the temperature falls below the dew point. The addition of glycol vapor should permit condensation with a lesser expansion, glycol in the droplets lowering their vapor pressure and causing them to grow in an atmosphere not saturated with water vapor. Reduction in

the expansion required, water vapor pressure being maintained constant, should thus indicate the vapor pressure of glycol. Experiments indicate that glycol does reduce the expansion required for condensation, and that the occurrence of condensation can serve to control the rate of addition of glycol to maintain constant glycol vapor pressure.

6. On Electron Microspectroscopy. L. MARTON, *Division of Electron Optics, Stanford University.*—The energy losses of fast electrons corresponding to K levels of light elements, and observed first by G. Ruthemann,[1,2] were used by J. Hillier[3] in an instrument designed for the investigation of the composition of small specimens. His instrument, called an "electron microanalyzer," consists of an inverted electron microscope producing a small probe on the surface of the specimen, with analysis of the transmitted beam and image formation by the shadow method. Our investigations show that the energy losses can be observed in a transmission type of electron microscope. For such a purpose an attachment is built on to the Stanford electron microscope replacing the transparent fluorescent screen used for end-on viewing the image. The attachment consists of a disk, coated with fluorescent material, and provided with a small slit through which part of the highly magnified image can be directed into a magnetic analyzer extending below the microscope. A simultaneous observation of both the highly magnified image and its velocity spectrum is therefore achieved. The area used for the velocity analysis can be made variable by changing the end magnification and keeping the slit width constant. The magnetic analyzer is of 135°, direction focusing type. Observation, temporarily at least, is on a fluorescent screen inclined toward the beam axis and approximately in the correct position for the velocity focal plane. Some of the obtained results are discussed.

[1] G. Ruthemann, Naturwiss. **29**, 648 (1941).
[2] G. Ruthemann, Naturwiss. **30**, 145 (1942).
[3] J. Hillier, Phys. Rev. **64**, 318 (1943).

Invited Papers

Specific Ionization and Energy Loss of Cosmic Rays. WAYNE E. HAZEN, *University of California.*

Microwave Oscillation Generators Using Velocity Modulated Electron Beams. EDWARD U. CONDON, *Westinghouse Research Laboratories.*

SATURDAY AFTERNOON AT 1:30 O'CLOCK

Room 212, LeConte Hall

Invited Papers

Applications of Radioactive Tracers to the Physiology of Plants. ROY OVERSTREET, *Experiment Station, College of Agriculture, and Radiation Laboratory, University of California.*

Some Aspects of our Present Understanding of Elementary Particles. JOSEPH W. WEINBERG, *University of California.*

7. X-Ray Monochromatization by Four Balanced Filters. PAUL KIRKPATRICK AND C. K. CHANG, *Stanford University.*—A limitation of Ross' balanced filter method is the physical impossibility of entirely suppressing $a-b$ outside the pass band, $a(\lambda)$ and $b(\lambda)$ being the fractions transmitted by filters A and B, respectively. This limitation may be surmounted by using two similar filters of element A and two of element B. From an x-ray source adjacent beams, defined by similar diaphragms, are allowed to pass to a common ion chamber. An ion current observation is made with the superposed A filters in one beam and the superposed B filters in the other. One A and one B filter are then transposed and a second current reading is taken. The difference between these currents is then a summation to which each wave-length contributes an amount proportional to $(a-b)^2$. In Ross' method the corresponding magnitude is $(a-b)$. Thus the contrast between the pass band contribution (where a/b may be of the order of 3) and the contribution from other spectral regions (where $a/b \doteq 1$) is greatly accentuated by the four-filter method and a monochromatic effect may be achieved with filters which have been only very roughly balanced.

8. Linearity of d.c. Vacuum-Tube Voltmeters. SEVILLE CHAPMAN, *Stanford University.*—In d.c. vacuum-tube voltmeters having a balanced double-triode circuit, the meter is usually connected between the plates of the two tubes. If, however, the load resistors are inserted in the cathode circuits, rather than in the plate circuits, and the meter is connected between the two cathodes, the plates being connected directly to power supply, it is shown that without loss of sensitivity the departure from linearity between input voltage and meter reading is reduced by a factor of from 2 to 4 in practical cases. Thus an increase

in sensitivity by a similar factor can be obtained, or a less sensitive meter may be used for performance equivalent to that of the usual circuit. When degeneration from additional cathode resistors is employed in the usual circuit, its performance is improved, but it does not equal that of the suggested circuit. Practical examples are compared with theoretical calculations. With an ordinary 250-volt unregulated power supply the suggested circuit will give a meter deflection of 1 milliampere per volt input with a single 6F8-G tube, sensitivity being independent of normal line voltage fluctuations. This high sensitivity arises from the low impedance of cathode loaded stages.

9. The Spiroton. LAURENCE E. DODD, *University of California at Los Angeles.*—As a means, theoretically possible, of stopping very high speed particles by deceleration using potential gradients applied in successive steps as in the cyclotron, but at the same time avoiding correspondingly high frequencies of field reversal, which may be impractical to obtain, the present paper proposes to whittle down such high velocity a selected component at a time. The name "spirotron" is given to such a design. The type of spiral implied by this term is that of a tapering helix rather than a plane curve as at present. A succession of several of these in series, of different pitches, with their axes at definite angles of inclination with each other, should serve to stop particles of higher velocity than could be dealt with in the reversed cyclotron because of frequency difficulties.

10. A Simple Adaptation of the Ultraviolet Photographic Spectrophotometer to Direct Visual Measurement. LOUIS A. STRAIT, W. D. KUMLER, AND FRANK M. GOYAN, *College of Pharmacy, University of California.*—The conventional u.v. photographic spectrophotometer of the rotating sector or stationary variable diaphragm type is adapted to direct visual measurement by substituting a fluorescent screen for the photographic plate. Monochromatic measurement of optical density or transmission may be made with speed comparable to conventional photoelectric photometers and there is an advantage in flexibility with regard to type and size of sample which may be measured. A quick survey of qualitative absorption may be made conveniently by using a Baly tube and observing the absorption spectrum on the screen. Where photographic photometry of an unknown is to be carried out, the desired concentration may be readily found in the same way, saving photographic plates as well as time. Potassium chromate solutions ranging in optical density at 2800A from 0.04 to 1.3 have been used, and the duplicate-measured transmission values deviate from the theoretical by a maximum of 3 percent with a mean deviation of 1.6 percent. More detailed data will be reported elsewhere. A suitable screen may be made by depositing a uniformly fine suspension of anthracene (in a base such as cellulose acetate or butvar) on a glass screen made by removing the emulsion from a photographic plate.

11. The Measurement of Absolute Efficiencies of Gamma-Ray Counters. WENDELL PEACOCK, *Massachusetts Institute of Technology.*—By measuring various radioactive isotopes, using coincidence counting methods, one may determine the absolute efficiency of gamma-counters and the absolute rate of disintegration of the radioactive isotopes. By the use of the isotopes Na^{24}, Co^{60}, Mn^{54}, I^{131}, Y^{86}, Fe^{59}, Mn^{56}, and Co^{58}, the absolute efficiency of screen wall copper, platinum, and bismuth counters was determined. With the isotopes Br^{82}, Au^{198}, I^{130}, Mn^{52}, Na^{22}, and V^{48}, the efficiency curves thus determined were confirmed. The efficiency curves thus obtained were in substantial agreement with the theory proposed by V. Droste. With several isotopes, each emitting a single monochromatic gamma-ray, it is possible to compare the efficiency of gamma-ray detecting instruments at various energies rather quickly. Isotopes with conveniently long half-lives and emitting gamma-rays of energies above 1.5 Mev are not yet available, but Be^{7}, Cu^{63}, Mn^{54}, and Zn^{65} serve at lower energies. By the use of these isotopes in connection with I^{86} and Na^{24}, the efficiency curve can be extended from 0.4 Mev to 2.75 Mev. The absolute efficiency of the measuring device can be obtained with a source for which the absolute disintegration rate is known. For this purpose Co^{60} (5.3*y*) has been used.

12. Direct and Fluorescence Excitation of the L_{III} Level in Thick Targets of Thorium. BURR G. BURBANK, *Stanford University* (Introduced by Paul Kirkpatrick).—The ratio P of the probability of exciting the L_{III} shell of thorium by direct electron bombardment to the probability of exciting the same shell by photoelectric ionization in a thick target was determined by observation of normally emergent x-rays from an oil-cooled thorium-target x-ray tube. The intensities at the peak of the $L\alpha_1$ line and in the continuous background on each side were measured with a Bragg spectrometer. The target was then covered with a palladium foil thick enough to stop all bombarding electrons, and these intensities were again measured. The $L\alpha_1$ line from the covered target could be produced only by the photoelectric ionization process, while the $L\alpha_1$ line from the bare target could be produced partly by each process. By taking into consideration the relative intensities and the mean depths of production of the continuous rays from the palladium and the thorium, P was calculated for a range of voltages from 40 to 100 kv, and was found to decrease from a value of 3.1 at 40 kv to 1.98 at 100 kv.

13. A High Voltage D.C. Regulator Entirely A.C. Operated. J. F. MCGEE, *Stanford University.*—The regulator is of the fundamental degenerative type, as catalogued by Hunt and Hickman[1] for low voltage applications and suggested for higher voltages. It is used in conjunction with a half-wave voltage-doubler power supply in the x-ray research laboratory. The present regulator circuit is distinguished from others of comparable stabilization in that: (a) it is entirely a.c. operated, the usual reference battery of several hundred volts being replaced by the highly regulated and separate plate supply voltage of the d.c. amplifier; (b) it makes use of an *RC* combination

which for short duration fluctuations of voltage has the effect of increasing the fraction of the high voltage that is compared with the reference voltage.

[1] F. V. Hunt and R. W. Hickman, Rev. Sci. Inst. **10**, 6 (1939).

14. Planck's Universal Constant of Action. SAMUEL R. COOK, *Sacramento, California.*—The paper purports to find a relation between Planck's two constants, the unit electric charge and what Planck called his universal "quantum of action" h. Planck considered that the two constants were independent, and that although the two constants were essential in developing his radiant heat formula, they were entirely independent of each other. The paper purports to show, first, that Planck's first constant, which he considered as a mere formal constant, is in reality the real universal constant of action, being the unit charge of electricity e. The paper also purports to show, second, that the ratio of the values of the two constants e and h is a definite constant of proportionality k. Since the discovery by Planck of the constant h, which when multiplied by the frequency of radiation gives the value of the energy of any radiation quantum $h\nu$, the exact explanation of the nature of the constant h has been in question. The paper shows that e, the electric charge on an electron, is the real "constant of action" and that h is a constant which acts as a factor to measure the energy developed in the radiation quantum developed by e. The ratio of e and h is determined as a constant k.

15. A New Method of Determining the Fraction of Electrons in Cosmic Radiation. ROBERT R. BROWN, *University of California* (Introduced by Wayne E. Hazen).—A cloud chamber containing seven lead plates, three of 0.2-cm thickness and four of 0.7-cm thickness, was operated by a three-counter telescope above the chamber. The counters were made of thin glass and the usual copper cylinder was replaced by a layer of graphite paint. Above the counters and the chamber was a thin metal roof. The equivalent stopping power of the thin metal roof, the walls of the counters, and the wall of the cloud chamber was ~10 Mev. The electrons and mesotrons that entered the chamber were differentiated by their shower effects, penetration, and ionization. The probability that an electron would pass through the chamber without initiating a shower is extremely small. On the other hand, the probability that a mesotron would initiate a shower while passing through the absorber is extremely small. The advantage of this method over that using a cloud chamber and a magnet is that the incoming particle spectrum is not distorted by a strong magnetic field. The advantage of this direct cloud-chamber method over the indirect counter method is that the cloud-chamber results depend on the cascade theory of showers only so far as the determination of the lower energy limit is concerned.

16. Rigorous Calculation of an Electrostatic Immersion Lens. RUDOLF G. E. HUTTER, *Division of Electron Optics, Stanford University.*—Previous investigations have shown that the electrostatic immersion lens, given by the axial potential distribution, $\phi(z)=\phi_0 e^{\kappa \arctan z/a}$, is the simplest electrostatic lens for which Newton's image equations are satisfied throughout the field. The axial potential distribution of this lens is found to approximate that of the electrostatic lens consisting of two cylinders of unequal radii which are connected to two potentials $V_1=\phi_0 e^{-\kappa\pi/2}$ and $V_2=\phi_0 e^{+\kappa\pi/2}$. The general solution of the paraxial ray differential equation is derived. Based on this solution and the fact that Newton's image equations are satisfied, exact expressions are derived for all important optical quantities such as the focal lengths, the location of the four cardinal points, the magnification, the object-image relation, and the spherical and chromatic aberration for any object position. The optimum positions of an object are determined so that the chromatic and spherical aberrations are reduced to a minimum. All quantities are represented graphically as functions of the ratio of the asymptotic voltages V_2/V_1. A plot of the equipotential lines in space is given for a special value of the voltage ratio.

SUPPLEMENTARY PROGRAMME

(To be called for after paper 16 if time permits.)

17. Theoretical Efficiencies of Continuous X-Ray Production. PAUL KIRKPATRICK, *Stanford University.*—Computations of continuous x-ray intensities on the basis of the Sommerfeld theory, as supplemented by subsequent contributors, have been completed for potentials to 90 kv, wave-lengths from 0.181A to 1.431A, and representative atomic numbers throughout the range. By combining these results with Williams' theory of the electron stopping power of matter, values of production efficiency have been obtained. The following table gives the ratios of emitted x-ray energy (all frequencies and all directions) to total energy loss suffered by electrons *of the stated energies* when traversing matter of the given Z.

Z	25 kv	40 kv	90 kv
13	0.0013	0.0018	0.0028
47	0.0048	0.0068	0.0115
70	0.0069	0.0097	0.017
92	0.0087	0.0125	0.021

The total continuous spectrum energy (in ergs) emitted during complete stoppage of a 90-kv electron is almost directly proportional to the atomic number of the stopping element, rising to 1.90×10^{-9} erg at $Z=92$.

18. The Mean Depth of Production of Continuous X-Rays in Thick Targets of Thorium. BURR G. BURBANK, *Stanford University* (Introduced by Paul Kirkpatrick).—

A thick target of thorium was bombarded by 40–100 kv electrons incident obliquely in a direction making a grazing angle of 30° with the target surface. The intensities of several selected wave-lengths of the continuous spectrum propagated in a direction at right angles to the direction of bombardment were observed with a Bragg spectrometer for a variety of orientations of the target with respect to an axis of rotation coinciding with the electron beam. By Stoddard's modification of Kulenkampff's method, the mean depths of production were deduced from the slope of a plot of the logarithm of the observed continuous intensity *vs.* the secant of the angle of rotation of the target. Mean depth values were obtained as functions of wave-length and bombardment voltage. The average value of the mean depth of production within the spectral range between the high frequency limit and the L_{III} absorption limit increases from 6.0×10^{-5} cm at 40 kv to 22.2×10^{-5} cm at 100 kv. The total range along the path of the electrons in the thorium, as calculated by Williams' formula, is about 10 times the average mean depth of production.

19. The Electronics of Lightning. SAMUEL R. COOK, *Sacramento, California.*—The paper purports to give a new and novel explanation of the nature of the origin and propagation of lightning. The most recent concepts of electricity and the electromagnetic field of the electronic charge are utilized in outlining the method of lightning propagation. The theory leads to a mode of propagation, by which is explained both the formation of the stationary stages or points of hesitation, as described by Schonland of South Africa, and the formation of the electronic avalanche which is observed in all lightning strokes, and which is the immediate source of the death-dealing phenomena frequently accompanying lightning. The ability of the lightning to ionize the air in its path is also explained as a novel process. The paper does not purport to explain many of the apparent pranks of lightning, but it does explain the branching, zigzag, and the return stroke. It recognizes the good experimental work of Schonland, Peck, McEachron and Patrick, and others, but affirms the very great need of more very careful research before the theory can be confirmed. It is hoped, however, that the theory will aid in directing this research.